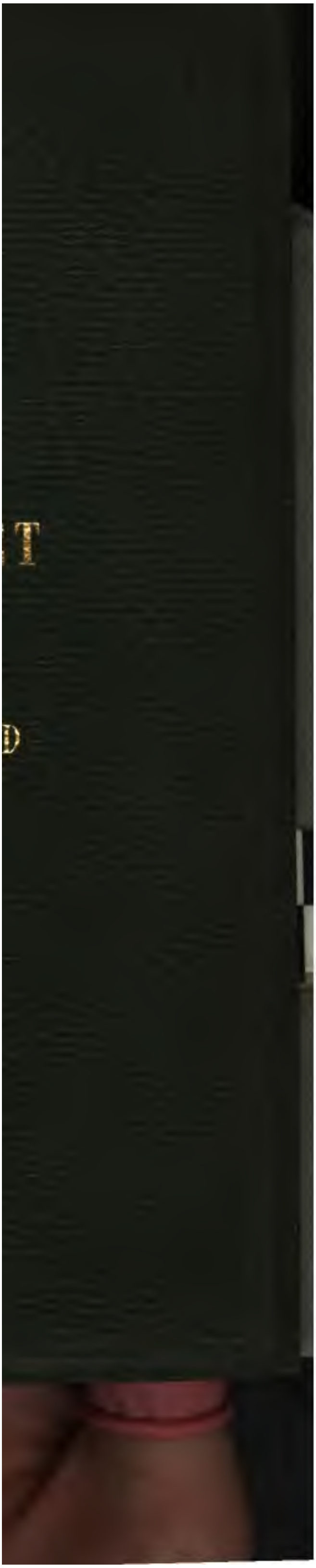

THE COMET

OF

1556.

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OF

1556;

BEING

POPULAR REPLIES TO EVERY-DAY QUESTIONS,

REFERRING TO

ITS ANTICIPATED RE-APPEARANCE,

WITH SOME OBSERVATIONS ON THE

APPREHENSION OF DANGER FROM COMETS.

By J. RUSSELL HIND,

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[The Author reserves to himself the right of Translation.]

TO

GEORGE BISHOP, ESQ., F.R.S.

PRESIDENT OF THE ROYAL ASTRONOMICAL SOCIETY,
ETC. ETC. ETC.

My dear Sir,

When I first requested your permission to dedicate to you, as a slight token of respect, a little work upon the expected comet, you are aware it was written in a more scientific and technical style than the pages now offered to the public; and I should hardly have ventured to ask for the same favour for the present treatise, did I not well know the deep interest you have always taken in the diffusion of Astronomical information of a popular kind, and your desire to encourage in others that zeal in the pursuit

of the science which for a long term of years has been known to actuate yourself.

Your kind acquiescence with that renewed request calls for the warmest thanks of,

My dear Sir,

Yours very truly,

J. R. HIND.

PREFACE.

IN the following pages I have attempted to supply popular answers to questions relating to the expected comet, and to comets generally, which have inundated me, in common, probably, with many others professionally engaged in astronomical pursuits, during the last four months. These replies have been jotted down, as opportunity offered, in the midst of many calls upon my time — a fact which, I fear, will be too evident from perusal. Nevertheless, while asking the reader's indulgence on this score, I venture to hope he will find, in these remarks, such popular information on the subject, as, in the event of his being unacquainted with scientific details, he would wish to meet with.

It has formed no part of my object to touch upon the *history* of the comets of 1264 and 1556, or upon the evidence which constitutes the foundation for the opinion long entertained as to their identity. I must refer the reader, for full information on these points, to a work published in 1848,* where will be found, in addition, a set of tables exhibiting the different paths in the heavens which the comet should follow, according to the season of the year when it becomes visible. The general grounds upon which I have there advocated the probable identity of the comets of 1264 and 1556, appear to me undisturbed, notwithstanding certain objections raised within the last few months by several foreign astronomers; and I must still maintain, that there is more than sufficient reason for prosecuting the rigorous search lately commenced in many European observatories, that the comet, unfavourably placed as it will be should it return in mid-winter, may not pass by unseen, through any want of attention or watchful-

* '*On the Expected Return of the Great Comet of* 1264 *and* 1556.' Hoby, 123, Mount Street, Berkeley Square.

ness. In the summer-time it would be conspicuous enough.

It has only recently transpired that the late Professor Gauss, of Göttingen, one of the most accomplished mathematicians of his day, was always of opinion, that the return of the comet of 1556 about the middle of the present century is 'very possible, though not certain.' The most that has been asserted, so far as I know, amounts to this,— the reappearance is an event of *fair probability*.

Should the perusal of these pages induce the reader to inquire further into some of the features of Cometary Astronomy, to which little more than an allusion could be made in so limited a space, he will find a general outline of the actual state of our knowledge of that branch of science in my descriptive work, "The Comets,"* with a catalogue of orbits, extending from the earliest times to the year 1852.

J. R. HIND.

LONDON,
July 6th, 1857.

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* J. W. Parker and Son, West Strand.

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THE COMET OF 1556,

ETC.

I.

Is it CERTAIN *that the great Comet of* 1556, *or, as it is frequently called in history,* THE COMET OF CHARLES V., *will re-appear about the present epoch?*

TO this query, it must be replied, that the visit of the Comet within the next few years, though not an event of *certainty,* is one to which, for upwards of three-quarters of a century, astronomers have attached *considerable probability.* It depends upon the correctness of the assumption that the Comet was identical with one which, from its extraordinary magnitude, created astonishment throughout Europe in the year 1264, or, in other words, upon the period required by the Comet to complete a revolution round the sun, amounting to somewhere about 300 years. No one thoroughly acquainted with the subject could, or has pretended to, assert positively that this celebrated body would become visible again in our time; it is not an occurrence which can be foretold with the same confidence as an eclipse, though,

as sometimes happens, the general public have taken in an absolute sense what should, strictly speaking, have been understood as a guarded prediction.

It is not, however, too much to state, that during the lapse of time we have named, the probable identity of the comets of 1264 and 1556 has been commonly admitted by those who have examined the question, or have written upon this branch of the science; and only within the last few months have any serious attempts been made to dispute it. To these objections we shall shortly allude further. Meanwhile, we are perhaps justified in citing, as an indication of the general tendency of astronomical opinion, the fact of an extensive and energetic search for the comet having been organised at some of the principal observatories of Europe, which would hardly have been done upon slight grounds. Amongst the establishments thus engaged may be mentioned, the Imperial Observatory of Paris, under the direction of M. Leverrier, who has given so marked an impulse to astronomy in France; the Observatory of Vienna, now presided over by Professor Littröw, to whom we are greatly indebted for his additions to our knowledge of the comet of 1556; the Observatory of Altona, in Denmark, under the superintendence of Professor Peters, one of the most able mathematicians of the present day; with many others. To these public institutions may be added a large number of observers, belonging to a class for which this country is pre-eminently distinguished—the amateurs of astronomy—private gentlemen of scientific tastes and ample means, who devote their leisure to

celestial observations, some of whom possess instruments as well adapted for the examination of the heavens as any that are to be found in the public observatories.

II.

Wherein consists the uncertainty attached to an approaching return of the Comet?

SIMPLY in the difficulty experienced in deciding upon the true orbit, or path in the solar system, of the comet of 1264.

If there be a great similarity between orbits assigned to comets appearing in different years, there is a strong probability that the comets were the same; and this probability is, of course, increased the closer the resemblance that is found to exist between them.

Now in 1556, the comet was observed in a much more precise manner than in 1264, though, at the same time, very roughly, compared with the methods now practised. Its path in the former year is therefore moderately well determined; and has lately been verified by an extensive series of positions, discovered by Professor Littröw of Vienna, which have been brought to bear upon the calculations. Until the year 1856, astronomers were in possession of only a very small and imperfect map, showing the track of the comet amongst the stars, as observed by

Paul Fabricius, who held the oddly-conjoined offices of physician and mathematician at the court of Charles V. of Austria, and who was supposed to have been the only trustworthy observer of the comet. Professor Littröw after a long research, succeeded in recovering, not only the original map published by Fabricius, which is on an enlarged scale compared with the chart previously known, but he also found a treatise, of which astronomers had no information, by one Joachim Heller, of Nuremberg, who traced the course of the comet for a much longer interval of time than Fabricius; and thereby furnishes us with the means of correcting, or rather of testing the accuracy of the path that had been assigned to the comet from a shorter course of observation. Unfortunately even these newly discovered details are involved in some obscurity, chiefly owing to the difficulty of identifying the stars near to which the comet is said to have passed; and it will presently appear how this affects the main question.

It will be understood, that the comet's orbit in 1556, is known with sufficient exactness to enable us to identify this body beyond much doubt, with others *equally well observed.* The case was different in 1264. The astronomy of Fabricius and Heller, was as far in advance of the science of the thirteenth century, as it was behind that of the present day. Instead of maps of the comet's track in the heavens, and attempts at observation by comparison with the places of the fixed stars, as in 1556, we find in 1264 little beyond the vague and frequently contradictory notices contained in the writings of con-

temporary historians. The Chinese annals, it is true, afford very important assistance, in fixing the apparent path of the comet; and, as usually happens, in these remote times, appear far more definite and worthy of confidence than the great majority of European descriptions, of the appearance and courses of these bodies. Still, with all the information we possess, the orbit of the comet of 1264 is not free from doubt, because the accounts that have descended to us are not sufficiently definite to form the basis for exact calculation. Thus much, however, was asserted by Pingré, the eminent French authority upon cometary astronomy in the last century, that the comet of 1264 was *very probably* the same as that of 1556, since it appeared after careful investigation that the general path of the comet in 1264 corresponded well with what it should have been, supposing the more-certainly-observed comet of 1556, had been visible in the former year.*

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* I have paid close attention to this subject for many years past, and am tolerably familiar with all the details that have descended to us respecting the comet of 1264. My opinion has long been, and still is, identical with that expressed a century since by Pingré, though founded entirely upon a new series of calculations, favoured as I have been by M. Biot's translation in full of the passages in the Chinese annals referring to the comet of 1264, of which Pingré had only a very imperfect transcript. The objections which have been recently advanced by several foreign astronomers (including Mr. Hoek of Leyden and Professor Valz of Marseilles) do not appear to me of any weight. At one time, I believe, I entertained similar doubts myself, but having subsequently found that the *whole mass of evidence fairly*

It may not be out of place, in order to give the reader who is innocent of such matters, an idea of the fanciful and frequently unintelligible records of comets or objects so called in the early chronicles, if a few extracts from the great work of Lubienietski, and from other authors, are here appended. After perusing them (and they are fair samples of a vast proportion of the contents of many of the compilations available for inquiring into the histories of these bodies), he will probably be at no loss to comprehend the nature of the difficulties which astronomers encounter, when they have to deal with an ancient comet.

A.D. 418. Philostorgius, a contemporary writer, has the following account of the comet of this year:—'The Emperor Theodosius was already entered into his years of adolescence; on the 19th of the month of July, about the eighth hour of the day, the sun was eclipsed to that degree that the stars were seen. Moreover, at the same time that the sun was thus obscured, there was seen in the heavens a light in the form of a cone: some ignorant people called it a *comet*: but in the phenomena of this light we saw nothing which announced a comet; for the light was not terminated by a chevelure; it resembled the flame of a torch, subsisting alone, without

considered, was decidedly in accordance with the supposition of identity, it appeared more reasonable to adopt this view of the matter, than by attributing unnecessary importance to the contradictory assertions of one or two ignorant writers, to call in question a theory otherwise supported by the general testimony of history.—THE AUTHOR.

any star to serve it for a base. Its movement, likewise, was very different from that of the comets: it was first seen to the east of the equinoxes; thence, having passed by the last star in the tail of the Bear, it slowly pursued its course to the west. After having thus traversed the whole sky, it finally disappeared, its course having continued more than four months. Its summit sometimes prolonged itself into a very long point; it then exceeded the measures and dimensions of the cone, afterwards it again assumed a conical figure. It commenced appearing about the middle of summer, and continued almost to the end of autumn.'

About the year 504, or 'in the time of Ambrose Aurelius, King of Great Britain, there was seen a star of prodigious magnitude and brilliancy: it had but a single ray, but this one was terminated by a fiery globe, resembling a dragon, from the mouth of which issued two rays; one appeared to extend towards France, the other, directed towards the Irish Sea, had seven smaller rays at its extremity.' If a comet really appeared in the above year, this is all we know about it.

Historians of the Eastern Empire tell us that the crimes of Andronicus, who in 1183 put to death the Emperor Alexis, and seized upon the government, were foreboded by a comet. 'It resembled a twisted serpent, at one time stretching itself out, at another, coiling itself up, and then to the great fright of the spectators, it opened a mouth of vast dimensions: the report went, that being thirsty after human blood, it was upon the point of satiating

itself. It was only seen during the rest of the day and the night following; afterwards vanishing altogether.'

The subjoined extract from the Byzantine History of Nicephoras Gregoras contains one of the most circumstantial descriptions of the path of a comet to be found in the chronicles of these remote times; and it is interesting to the astronomer as having been the earliest account which Halley made use of when applying the Newtonian law of gravitation to the motions of the comets: 'The sun having attained the summer solstice, the comet commenced appearing every evening, towards the northern parts of the horizon; it seemed to have had its origin near the feet of Perseus, which are not far distant from the back of Taurus. Its chevelure extended far towards the east. Leaving the feet of Perseus, this star advanced daily about 3° northward. Having passed the north pole, it traversed Ursa Minor, the folds of Draco, touched the right foot of Hercules, and passed by Corona and the left hand of Serpentarius: lastly, its chevelure being dissipated, it ceased to exist.' This applies to the comet of the year 1337.

The following quaint description of the comet of 1472, first published in the *Philosophical Magazine*,* affords so excellent an example of cometary records of this date, that we make no apology for introducing it here.

'And in same xi yere of the kynge, in the begynnynge of Januarii, there apperyd the most

* Vol. xiv. (New Series) p. 260.

mervelous blasynge sterre that hade bene seyn. It aroose in the South-Este at ij of the cloke at mydnyght, and so contynued a xij nyghtes, and it arose ester and ester till it aroose full este and rather. And so when it roose playn Est, it rose at x of cloke in the nyght, and kept his cours flamynge Westward overe Englond; and it hade a white flaume of fyre fervently brennynge, and it flamed endlonges fro the Est to the Weste, and noght upright; and a grete hole theirin, whereof the flawme cam oute of. And after a vj or vjj dayes it aroose North-Est, and so bakkere and bakkere, and so enduryd a xiijj nyghts full lytell chaungynge, goynge from the North-Este to the Weste; and sometyme it wuld seme a quenched oute, and sodanly it brent fervently ageyn, and then it was at one tyme playne north, and then it compassed rounde aboute the lode sterre, for in the evynynge the blase went ageyns the Southe. And in the mornynge playne northe, and then afterward West, and so more West flamyng vpryght, and so the star contynued iiij wekys tylle the xx day of ffeveryere; and when it appered West in the fyrmament, then it lasted alle the nyght, somewhat discendyng with a grettere smoke on the heyre; and som men seyd that the blassynges of the seid sterre was of a myle lengh; and a xjj dayes afore the vanyschynge thereof it appereryd in the evenyng, and was down anon within two oures, and evyr of a colour pale stedfast; and it kept this course rysynge west in the northe, and so every nyght it apperid lasse and lasse tyll it was as lytell as a hesyll styke, and so at the laste it

vanesched away the xx day of ffebruarii. And some men said that this sterre was seen ii or iii oures afore the sunne rysynge in Decembre iijj days before Chrystynmasse in the Southwest, so by that reasoune it compassed round abowte all the erthe alleway chaungyng his cours as is afore rehersid.'

The author of the above curious notes was John Warkworth, Master of St. Peter's College, Cambridge. They are extracted from an autograph chronicle of English affairs, preserved in Peterhouse Library.

Here we have the particulars of a phenomenon, duly honoured with the name of *comet,* by writers of the time, but in all probability an aerolite-cloud, similar to those which are occasionally remarked in the heavens for an hour or more, in the position where one of these meteors has exploded. 'In the year 1527, on the 11th of October, or, as others say, on the 11th of August, about 4 o'clock in the morning, there appeared, not only in the Palatine of the Rhine, but over nearly the whole of Europe, a terrible comet, which burned for an hour and a quarter.* In its length, which was immense, it was of a bloody colour, inclining to saffron. At the top it had the form of a bended arm, in the hand whereof was seen a huge sword in the act of striking. At the extremity of the sword were three stars, of which the largest was at the point. From these issued dusky rays, in the form of a hairy tail. From the sides other rays were perceived, stretching

* One writer adds '*daily.*'

downwards like javelins or smaller swords, tinged with the colour of blood, between which were human faces resembling blackish clouds with bristly hair and beards. The whole moved while sparkling in such terrific manner, that many of the spectators were almost lifeless with fear.'

A few years since, Professor Bond, of the Cambridge Observatory, Massachusetts, published an account of a great meteor,* which he witnessed with many other observers, that might have been described in similar language to the above, supposing it to have occurred three hundred years earlier, when such objects excited the terrors of mankind.

After these extracts from the European Chronicles, the reader may like to have one or two from the annals of the Chinese empire, by way of comparison.

The following relates to a comet which appears to have moved in an orbit very similar to that of the one we are now expecting, though perhaps less inclined to the earth's path:—

A.D. 178. 'In the first year of the period Kouang-ho, in the 8th Moon, a comet was seen to the north of the group *Kang*. It entered into the middle of *Tien-che*. It was at first a few degrees long; gradually it increased to 50° and 60°. Its colour was red: it traversed nearly ten stellar divisions, and after having appeared 80 days it was extinguished in the middle of the *Thien-youen*.'

With the help of the Chinese planispheres, many of which exist in Europe, we are enabled to identify

* See *The Athenæum* of November 16th, 1850.

the groups of stars named in this account of the comet of 178, and thus ascertain its apparent track in the heavens. *Kang* is composed of the stars marked on our globes κ and ι in the zodiacal constellation Virgo. The centre of *Tien-che*, or the 'Celestial Market,' indicates the region about the heads of Ophiuchus and Hercules, while the Chinese *Thien-youen* corresponds to a part of our constellation Eridanus. This comet had, therefore, a very extensive journey in the sky, and by a tentative process, we may accordingly find the elements of the true orbit, with a considerable degree of probability.

Subjoined, is an extract from the same annals, detailing the course of a comet in the year 11 before the Christian Era, which there is strong reason for supposing to have been none other than the famous comet of Halley—last visible in the autumn of 1835, and revolving about the sun in an average period of 76 years.* If this be the fact, it is the earliest apparition that history enables us to recognise, and will always possess an especial interest and importance. The groups of stars, etc., designated by the Chinese observers, are given within the brackets.

'In the first year of *Youen-yen*, 7th moon, day *Sin-ouei* (B.C. 11, August 26), a comet was seen in the celestial division, *Toung-tsing* (determined by μ in Gemini). It passed over the five *Tchoui-heou* (the stars θ, τ, ι, υ and ϕ in the same constellation),

* On the early history of this remarkable body, see *The Comets*, and a paper inserted in the *Monthly Notices* of the Royal Astronomical Society for January, 1850.

appeared to the north of *Ho-su* (the space between Castor and Pollux, and the two bright stars in Canis Minor), and directed itself towards *Hien-youen* (the head of Leo), and the *Thai-wei* (the region about the star marked β in the tail of Leo). Subsequently in the course of a day, it travelled more than 6°; in the morning it appeared to the east. On the 13th day, it appeared in the evening to the west. It passed over the *Tse-fei* (ζ, μ and ϵ in Leo). Thence it passed into the interior of *Nan-koung* (the same as *Thai-wei* or nearly so) the *Ta-ho-tang* (or 'Hall of the Great Fire'). Afterwards it encompassed the Via Lactea. The comet being without the abode of the Empress (the fore-part of the Constellation Leo), moved away in the degrees to the south: it passed over *Ta-kio* (Arcturus), the *Che-ti* (the legs of Boötes): it reached the Celestial Market, and then moved slowly: entering the same, it remained there during the decline of the moon, and left it to the west. On the 56th day, it set with the Blue Dragon (a term signifying the region of the heavens around the stars π and σ in Scorpio).'

It is upon such descriptions as the above that the astronomical calculator is obliged to rely, in computing the paths of ancient comets through this part of the solar system; nor will it occasion surprise, that with such data before us, diversity of opinion should frequently arise on the identity of one or other of the comets so recorded, with any of those observed in modern times.

III.

The Comet having been visible in 1264 *and in* 1556, *or after a lapse of* 292 *years, should it not have again presented itself after a similar space of time, or in the year* 1848?

IT is in the highest degree improbable that two successive revolutions of a comet requiring so long a period to complete its circuit round the sun, should have *precisely* the same duration. It is true, if a comet experienced no *resistance* while performing its journey round that luminary, it *would* make its appearance after *equal* intervals of time, so that when once the length of a revolution had been ascertained, it would be necessary merely to add it to the date of each arrival at the least distance from the sun, in order to find the epoch of the ensuing appearance. But the movements of comets are greatly disturbed by the *attraction* of the various planets belonging to the solar system, particularly by Jupiter and Saturn, which far exceed the rest in magnitude. This attraction is proportioned to the mass or weight of each planet, and, inversely, to its distance from the comet. It will, therefore, happen that a comet approaching near to a planet of great weight or mass, will experience a large alteration in its rate of movement, and hence originates an important effect upon the time of its next visibility from the earth. So far from being equable, the daily journey of a comet is a very variable quantity, and it is obviously on this account

very unlikely that two complete circuits round the sun should occupy the same number of years. Without any calculation, then, we may reply to the above inquiry, that the return of the comet *in* 1848 was not an event on which reliance could be placed; on the contrary, we should rather look for a difference of a few years in the lengths of the successive revolutions.

IV.

How do astronomers ascertain the effect of the attractions of the planets upon the time of a comet's appearance?

THIS problem is one of extreme labour and intricacy in its practical application, but the *principle* involved is not difficult of comprehension, and we will, therefore, say a few words upon it, avoiding all technicalities, and confining ourselves to the most simple form in which the question presents itself.

Suppose, for example, it is desired to calculate the effect of the attractions of Jupiter and Saturn upon the velocity of a comet for 1,000 days after a certain date, or, in other words, that we wish to find how much its velocity at the end of 1,000 days will differ from what it was at the commencement. The disturbing force of either planet will not increase or decrease uniformly, but in order to allow of the assumption of equable variation in a certain time being applied without entailing sensible error on the

final result, the whole period of 1,000 days is divided into a number of equal intervals, say of 50 days each. The next step is to ascertain from tables of the motions of the planets (such as have long been in the possession of astronomers, and which they are constantly occupied in improving) their positions for the *middle date* in each interval of 50 days; and from the known path of the comet in the system, we find its places for the same times, and thus proceed to determine the comet's distance from each planet, which constitutes an important step in the calculations. Then, as we know the respective masses or weights of Jupiter and Saturn, it is possible to arrive at the amount of their disturbing forces, and so to find to what extent the comet's velocity will be changed by this cause in every interval of 50 days, supposing the alteration to be at an equable rate during that space of time. It is evident, that if we add the whole of these variations together, i. e. the whole of the successive changes during the twenty intervals into which the 1,000 days were divided, we shall know how far the velocity has been affected at the termination of the period; and by applying this sum to the known velocity at its commencement, we find at what rate the comet moves after 1,000 days have elapsed.

It is necessary to conduct these calculations separately for each planet, proceeding as if the other had no existence, to an advanced stage in the work, when the disturbances produced by the two are united, and the computations finished. In predicting the time of reappearance of a comet, it is clear

that we have to find in what period, starting from the moment when it was previously at its *least* distance from the sun, it would again arrive at that point, allowing for the attraction of the various planets; but, as in the above case, we know the comet's average velocity during each interval into which the whole period may be divided, we can easily determine how far along its orbit, it has advanced at the expiration of every interval, and so find when the entire revolution round the sun will be completed.

Such is essentially the method upon which astronomers proceed to ascertain the amount of acceleration or retardation in the arrival of any comet, due to the attraction of the planets. The calculations in most cases are excessively long and troublesome, and it requires a practised computer, and one well acquainted with mathematical astronomy to deal with the subject effectively.

The success which has attended calculations of this nature has frequently been so complete, as to appear hardly credible to those who are unacquainted with the resources of theoretical and practical astronomy in the nineteenth century. We may instance the case of Halley's comet, which, as already remarked, performs its revolution in about seventy-six years, and has never been visible to us so long as ten months at any of its returns to these parts of the solar system. The time of the predicted arrival of this body in 1835 was in error only a few days. Starting from its previous appearance in the spring of the year 1759, several eminent mathema-

ticians had computed the effect of planetary attraction upon its movements during its absence of three-quarters of a century: amongst them was M. de Pontecoulant, of Paris, who gained the prize offered in connection with this subject by the Academy of Sciences in that city. After determining the amount of perturbation due to the disturbances produced by the Earth, Jupiter, Saturn, and Uranus, on the motion of the comet, and revising his computations with a more exact value of the mass of Jupiter than was at first employed, Pontecoulant announced that the comet would attain the lower end of its elliptic orbit, or pass its perihelion point at ten o'clock on the night of November 12th, 1835, Paris time. The observations of that year have shown that it actually reached this point at eleven, a.m., on November 16th, which exhibits an error of prediction amounting to only three and a half days, though the comet had been invisible upwards of seventy-six years. And there can be little doubt — considering the rapid progress of astronomy, and the additions to our knowledge which may be reasonably expected before the calculations necessary for fixing the time of its next visit are commenced, that a still greater success will attend the prediction for the year 1912.

The successive re-appearances of the comet which bears the name of Encke, the Prussian astronomer, who first ascertained the shortness of its period (about 1208 days, or three and a third years) are regularly foretold within a *very small fraction of a day*: a difference much larger than this would excite surprise in those who are conversant with

such matters, and would be immediately ascribed to oversight or imperfection in the calculations.

As a third example, the success attending the prediction of Biela's comet for 1846 may be mentioned. The period of this comet is only six and three-quarter years; but owing to the very unfavourable position of its path in the heavens at its previous return in the summer of 1839, no observations could be made that year. The computations had therefore to be carried forward from 1832 to 1846, or over about fourteen years instead of seven, i.e. through *two* revolutions. Yet the error of Professor Santini's epoch for the perihelion passage, in 1846, was only about nine hours, an agreement which Professor Challis characterized as *marvellous*, and allowing for the peculiar circumstances of the case, it undoubtedly was so.

When a comet is not very near the earth, and the time of its arrival at the least distance from the sun is only a few hours different from that predicted, the accordance between the actual place in the heavens and that computed, will frequently be so close that the unassisted eye could not detect any deviation therefrom.

V.

When is the Comet likely to be visible?

OWING to the imperfection of the old observations it is not practicable to assign the period when we may expect to see this comet within very narrow limits. Recent calculations indicate that it should appear *between the years* 1857 *and* 1861: the reasons for this conclusion will be seen presently.

It will be easily understood from what has already been said respecting the method of determining the effect of the attractions of planets upon a comet's movements, that before we can predict the time of its return, allowing for the delay or acceleration due to these disturbing influences, or indeed, before we can even start with our calculations, it is essential to know at what velocity the comet was moving when *last* visible—in the year 1556. It will not do to assume that it was exactly such, as to correspond to an entire revolution in 291¾ years, since that period, which is the interval between two actual appearances, must of course involve the effect of planetary perturbation during nearly three centuries. Hence arises the necessity for a very long and intricate mass of computation with the object of eliminating, or separating, the attraction of the planets, from the comet's movement. This being done, we have a starting point in 1556, because we can then find the real velocity in the month of April in that year when the comet *commenced* its present revolution, and, by continuing the calculation of the disturbances due to

attraction of the planets, we are then able to fix the time when it will have *completed* its journey round the sun, and again disclose itself to our view.

All this is familiar to the Astronomer so far as the *principle* is concerned; but the practical application involves calculations of so extremely laborious and troublesome a character, that it was perhaps hardly to be expected, such an amount of work connected with a problematical inquiry would be attempted. Nevertheless the difficulties standing in way of the solution of the problem were not sufficient to deter one able mathematician from undertaking this irksome task. A few years since, Mr. Bomme of Middleburg, a member of the Legislative Assembly of the Netherlands, published a memoir in which he gave the results of a thorough investigation of the effect of planetary disturbance upon the movements of the comet since the year 1264, or through a period of nearly six centuries. The more credit is due to Mr. Bomme for this important contribution to our knowledge of the subject, since it was only during the leisure which his public duties allowed him that he was able to work at his calculations. There can be no doubt that if Mr. Bomme had not attacked and solved the problem in this energetic manner, the return of the comet would long since have been given up as hopeless,—for, there are probably few Astronomers who would have anticipated the great discordance which is found to exist between the interval of perihelion passages in 1264 and 1556 and the actual period of revolution corresponding to the comet's velocity when last visible. Not to trouble the reader with more

numerical details than are necessary, we shall very briefly record the results of two independent sets of calculation by Mr. Bomme, the one based upon the orbit which Halley assigned to the comet in 1556, the other founded upon an orbit given by the author from a revision of the observations of Fabricius at Vienna to which we have before alluded, but prior to the discovery by Professor Littröw of the original chart in which those observations are laid down.

When Halley's orbit was adopted, it was found that at the rate the comet moved when last visible to us in April, 1556, it would require upwards of three hundred and nine years to perform an entire revolution, which is no less than seventeen and a half years longer than the interval between 1264 and 1556; wherefore, if it moved undisturbed by the attraction of the planets, it would not be due until the middle of the year 1865. But the disturbances arising from this cause, were found to accelerate it five years within a fraction; and, consequently, the comet should make its appearance in August, 1860.

With the author's orbit, the comet would be moving, when last seen, at a velocity requiring rather more than three hundred and eight years for the completion of its journey round the sun; and hence, if undisturbed, we might look for its return in the summer of 1864. The perturbations of the great planets are larger than in the former case, amounting to something over six years in the entire revolution, which is shortened thereby. Allowing for this acceleration, the comet is found to be due early in August, 1858.

We see then, that the differences between the orbits, leave an uncertainty of two years in the period of the comet's approaching visit. But is this an accurate measure of the limits within which the comet of 1556 *must* appear, if it were really identical with that of 1264? Scarcely so; it is *most probable* that the re-appearance will occur between the above dates; though, at the same time, quite *possible* that it might occur a year earlier or later. Oddly enough, the two orbits employed by Mr. Bomme in his investigations, differ nearly as much as those obtained from the recently discovered observations of Joachim Heller, in 1556, on what may be regarded as extreme hypotheses, with respect to the apparent track of the comet in April; in other words, on one assumption, we have an orbit nearly identical with Halley's; on another, it approaches very close to that given some years since by the author. The latter, which has been lately confirmed by a German mathematician, represents the general course of the comet, the best of the two, but is still open to objections. So far, then, as uncertainty in the orbit is concerned, we shall, perhaps, not be far wrong in supposing it commensurate with the differences between the two sets of numbers used by Mr. Bomme.

Yet there is another source of doubt, the bearing of which upon the main question, it is not easy to see, without a thorough revision of the whole computation of planetary disturbances between 1264 and the present time. Mr. Bomme's work, though most elaborately executed, must be considered rather

in the light of a first approximation, than as affording the *precise* result of the attraction of the larger planets upon the comet's movements. This arises from the nature of the problem, and is unavoidable in such a case as the present. Mr. Bomme, of course, was fully aware of the circumstance, and some time ago informed us of his intention to repeat a portion of his calculations, hoping thereby to fix the period of the comet's return, so far as it depended upon perturbation, within about three months. It may, however, be questioned, whether in the actual state of our knowledge of the orbit of the comet, a second approximation would lead to a more trustworthy result than we already possess.

An attentive consideration of the various points leads us to infer, that the comet of 1556 will return between the years 1857 and 1861 (always supposing it to be the same as that of 1264), but that it is impracticable to determine the exact epoch, with the imperfect data in our possession. There are one or two reasons why a preference might be claimed for the year 1858; not, however, of sufficient importance to outweigh the evidence in favour of a later period.

VI.

In what part of the Heavens will the Comet be visible?

WE have just attempted to give some elucidation of the method of finding at what epoch the return of a periodical comet may be expected, i.e., at what date it will reach its least distance from the sun. Unless we know this, it is impossible to say exactly where it must be sought. At one time of the year it may be seen in the east; at another, in the west: in winter, possibly, we may find the comet a conspicuous object in our midnight sky: in summer it may only ascend above our horizon during daylight, and so escape observation altogether. A comet which describes a certain path in June, say from Cassiopeia, over the Pole-star to the Great Bear, could not be identical with one which followed precisely the same track at Christmas.

If the comet we are now expecting should attain the lower end of its ellipse on or about May 11th, it would first become perceptible somewhere about the junction of the constellations Virgo, Corvus, and Crater, south of the celestial equator: after moving slowly for some weeks, it would take a rapid sweep northward, through Leo and Leo Minor to the head of Ursa Major, where it would be situate at the beginning of April. Thence passing through Camelopardus, it would be observed in Andromeda at the end of the same month, and probably be finally lost in the Zodiacal constellation Aries.

With the help of a globe, the above track may be compared with the following, which must be the course of the comet amongst the stars, when its arrival at the lower end of the orbit occurs on or about the 19th of August. It would first present itself in the evening twilight on the confines of Leo and Coma Berenicis, and after passing conjunction with the Sun, would become conspicuous in the southern parts of the world towards the end of September; and might be observed in Dorado on the 28th of that month, having traversed Hydra and Argo on its way from the Sun's place. Thence it would pursue its journey through Horologium into Apparatus Sculptoris, when its distance from the celestial equator southwards would have diminished far enough to allow of observation in Europe.

By assuming different times of the year for the comet's arrival at its least distance from the Sun, and then calculating its position in the heavens for various dates on the several suppositions, what are technically called 'sweeping-lines,' may be found, in or near to which the comet must be sought. If we knew the precise time of its reaching the end of its orbit, we should merely have to search within very confined limits; but the uncertainty attaching to this, renders a much more extensive examination essential.*

At great distances from the Sun, the comet of 1556 will always be situate below the head of Hydra, and we may be sure that, whether it be the same as

* See the Author's former work 'On the Expected Return etc,' for detailed information on these points.

that of 1264 or not, in this region of the heavens it must be located, though far beyond the reach of our telescopes. If it re-appear, it will issue forth from the constellation Hydra,—its after-path amongst the stars depending upon the season of the year, as just shewn.

When the period of a comet's revolution is definitely ascertained, there is no difficulty in assigning its exact position in the sky. The astronomer is able, in such a case, to point his telescope in a particular direction, and confidently assert that the wanderer is within the field of view, though beyond the limits of vision. We might thus trace the course of Halley's comet until it again unfolds itself to our eyes, in the year 1912.

VII.

Is danger to be apprehended from the near approach of a Comet to the Earth, or from its collision with our Globe?

THE subject to which this question relates, is not one that is usually discussed in any detail in astronomical works. The professors of the science at the present day are accustomed to smile at the popular alarm which occasionally shows itself so conspicuously on the announcement of a comet; but the reasons for the feeling of security thereby evinced are not generally understood. We propose, in our remarks, to glance at the origin and early history of

the apprehension of danger from comets; and after bringing under the reader's notice a number of facts which relate to the physical constitution of these bodies, to state briefly what appears to us the most legitimate answer to the above often-repeated inquiry.

Prior to the advent of the famous comet of 1680, which excited astonishment throughout the world from its extraordinary size, these mysterious objects were regarded merely with a superstitious awe as the omens of evil to mankind,—foreboding war and pestilence, famine, earthquakes, inundations, and a host of other dire consequences. Louis le Debonnaire, when asked why he evinced a dread of the comet of 837, which was flaming in the sky, replied, to the effect that he felt no fear of the comet itself, but he was alarmed at 'the signification of that sign.'* This remark conveys an idea of the kind of feeling inspired by the presence of comets in former times: we find little or nothing in history to lead us to infer that they were expected to cause *direct* injury to the earth; indeed, being almost universally placed amongst the larger meteors, and often confounded with them, it is not probable the notion was ever seriously entertained.

The appearance of the extraordinary comet of 1680 gave a more definite form to cometary apprehensions. Our countryman, Dr. Halley, one of the most eminent philosophers of his day, and the second of the English Astronomers Royal, applying the Newtonian theory

* In this instance his own death.

to the, apparently, capricious movements of these wanderers, announced as one result of his calculations relating to the tremendous comet of 1680, that at 1 o'clock on the afternoon of November 11th, it was not above a semi-diameter of the Sun (which he took to be equal to the distance of the Moon), 'northwards of the way of the Earth': and, he remarked 'without doubt by its centripetal force (which with the great Newton, I suppose proportional to the bulk or quantity of matter in the comet) it would have produced some change in the situation and species of the Earth's orbit and in the length of the year. But may the great good God avert a shock or contact of such great bodies moving with such forces (which, however, is manifestly by no means impossible), lest this most beautiful order of things be entirely destroyed and reduced into its ancient chaos.'

The expression of this fear by one in Halley's position, appears to have originated the apprehension of injurious consequences from the near approach of a comet, which has more or less prevailed in the public mind even down to the present day.

Newton considered that the comet of 1680, when in perihelion or at its least distance from the Sun, must have experienced a heat which he estimated at several thousand times greater than that of red-hot iron. For this body almost fell upon the solar orb: at noon on the 18th of December its distance from the surface of the Sun was less than 150,000 miles. The effect of so close an appulse, Newton declared would be to raise the comet's temperature to such an extreme that it could not cool down again, until after

the lapse of many ages: but the period of the comet's revolution being then supposed to amount to 575 years, it followed that its material must always remain in a state of intense heat. Speaking of comets in general, however, the same illustrious philosopher stated his opinion, that the vapours of which they were composed might be attracted to the planets and intermix with their atmospheres, adding his suspicion that such vapours formed the 'best part of our air, and which is absolutely necessary for the life and being of all things.' And he concluded 'so far are they from portending any hurt or mischief to us, which the natural fears of men are apt to suggest from the appearance of anything which is uncommon and astonishing.'

Whiston, the learned but fanciful Professor of Mathematics in the University of Cambridge, contributed not a little to fan the flame which Halley had called into existence. His *Theory of the Earth*, a work which attracted great attention at the time it was published, contains an elaborate exposition of his views relative to the cause of the universal deluge; the final destruction of all things by a general conflagration, and other questions bearing upon the Earth's past and future history.

He attributed the Earth's diurnal rotation on her axis to an oblique shock from this comet, and at great length endeavoured to prove that the same body passed so near us at the very time when the deluge was fixed by Chronologists, that the earth must have been enveloped in the atmosphere and tail of the comet, whence arose the forty days' rain, which led to

the destruction of the ancient world: and in similar detail he discusses the phenomena of the general conflagration. Some of these are horrible enough: here is a specimen. 'The atmosphere of the Earth, before the conflagration begins, will be oppressed with meteors, exhalations and steams; and these in so dreadful a manner, in such prodigious quantities, and with such wild confused motions and agitations, that the Sun and Moon will have the most frightful and hideous countenances, and their ancient splendour will be entirely obscured: the Stars will seem to fall from Heaven, and all manner of horrid representations will terrify the inhabitants of the Earth.'

Dr. John Keill, Professor of Astronomy in the sister University, though an opponent to a certain extent of Whiston's views, admitted that 'he had made greater discoveries, and proceeded on more philosophical principles, than all the theorists before him had done.' Keill thought there were very strange coincidences in them, which, he remarked, 'made it indeed probable that a comet at the time of the Deluge passed by the earth.'

Those who are curious in these and similar speculations, will find probably more than enough to satisfy them in Whiston's volume. It exemplifies how far a fanciful imagination influenced the judgment of a man who was really a scholar.

To such announcements from astronomical quarters, we may trace the rise of the popular apprehension when great comets have been visible or predicted. Nor are we without passages in the works of several philosophers, who have lived nearer to the present

epoch, which might appear to warrant alarm under those circumstances. The celebrated French geometer, Laplace, thus describes the probable effects of a collision of the earth with a large comet. 'It is easy to represent the consequences of the earth's encountering the shock of a comet. The axis and motion of rotation being changed, the seas abandon their former position and rush to the new equator: great part of men and animals are drowned in the universal deluge, or destroyed by the violent shock to the terrestial globe: entire species annihilated, all the monuments of human industry swept away; such are the disasters which might be produced.'

More than one comet, we know, has experienced an entire change of orbit from approaching near the great planet Jupiter, by far the most massive in the system. The comet of 1770 on two occasions became entangled amongst the satellites of this planet. In descending towards the sun in July, 1779, so large were the perturbations it underwent, that instead of completing its revolution and paying us a visit in the year 1780 or thereabouts, it was thrown off into quite a different path, which will not permit of its coming sufficiently near the sun to be within reach even of our most powerful telescopes. The distance between the comet and Jupiter towards the end of July, 1779, was little more than 450,000 miles, or about the distance of the second of his moons. We might thence infer, that if the comet possessed any attraction, i.e. if it were sufficiently massive to attract, it must have reacted upon Jupiter and his satellites, and have left unmistakeable signs

of its having passed in their vicinity, either by diminishing or lengthening their times of revolution, or by distorting, in some way or other, the relative positions of the paths they described prior to the comet's appearance amongst them. Yet we have positive proof that no such effects followed, and are therefore justified in concluding, that the mass of the comet was excessively small. Had a *solid* body of cometary dimensions traversed the system of Jupiter in the same way, the results would doubtless have been widely different, and the Jovian *Times* might have announced some awkward facts.

From this and similar instances,* it appears, that while comets may undergo almost any amount of perturbation from the attraction of the planets, they are not competent to produce an appreciable effect on the *movements* of the latter. It is just possible there may be a few comets which could tell a different tale; but there is every reason to suppose, that the

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* Some years ago, I ventured to point out the probability that the comet of Brorsen, at present revolving in an orbit of about five and a half years' period, might have undergone a great change in its path through the solar system by the overpowering attraction of Jupiter, near to which I found the comet should have passed on the 19th of May, 1842. Professor d'Arrest, of Leipsic, has just published the details of an investigation which quite confirm the above suggestion. He finds the comet was nearest to the planet during the night of May 20th; and that, previous to its entrance into the sphere of Jupiter's action, it did not for many years approach closer to the sun than about the distance of the planet Mars, whereas it now advances within the orbit of Venus.—*The Author.*

remark is applicable to the vast majority of these singular bodies.

Stars of a very faint class have been distinctly seen through the nebulosity of a comet, even near or in its densest part, though, as found by careful measurement and calculation, the diameter of the comet has exceeded 50,000 or 100,000 miles. Indeed, since powerful telescopes have come into general use, phenomena of the like kind are so frequently witnessed, that they attract no marked attention from the practised observer. A thin mist or a very slight haze in our atmosphere would suffice to obliterate stars of so faint a description as some of those which have been perceived, shining undimmed through 50,000 miles of cometic nebulosity. Even to call such objects *vapourish,* appears to convey a notion of greater consistency than they can possess.

The preceding observations will apply to by far the larger number of comets, which become visible from the earth. Still, it is not improbable, that there are occasionally, within the planetary spaces, comets which can boast of a nearer approach to solidity, if they do not actually possess a planet-like body within their nebulosities. We have the high testimony of the late Sir William Herschel respecting the visibility of a planetary point or disc within the head of the great comet of 1811. It was of a bluish green colour and rather over four hundred miles in diameter. A similar appearance was remarked in the comet of 1807; which, though greatly inferior in brightness to that of 1811, was yet a fine object: in this case, Sir W. Herschel as-

signed a diameter of about five hundred and forty miles. Other instances might be mentioned, but they form rare exceptions to the general rule. A person who contented himself with viewing a large comet through a very small telescope, would often be impressed with the conviction that the nucleus was of a planetary character; but, if he examined the same comet with a high magnifying power, he would probably find, in nine cases out of ten, that every trace of solidity had vanished. The beautiful comet which became suddenly visible in our northern heavens early in June, 1845, when viewed in an opera-glass or a telescope of low power, exhibited in the centre of the head a round, sharply-defined, disc-like nucleus, resembling in colour, though somewhat smaller than, the planet Jupiter. An inexperienced observer so regarding it, would doubtless have pronounced in favour of its solid or planetary nature. A telescope of greater pretensions, however, showed it under a very different aspect. The rigid appearance of the border vanished, it first looked furred or woolly, and, as the power was increased, entirely lost its well-defined appearance, and became nothing more than the denser portion of the great nebulosity forming the head of the comet.

There are one or two instances on record, where a comet, in passing over a star, so far from diminishing its brilliancy, has increased its light in a very marked degree. The fact rests upon the testimony of several eminent observers, including the late Professor Piazzi, director of the Observatory at Palermo. This astronomer, while engaged in watch-

ing the great comet of 1811, remarked that a star, subsequently invisible to the naked eye was so strongly illuminated, when the cometic atmosphere or photosphere was over it, as to be distinctly seen without the telescope. We have elsewhere* alluded to a similar augmentation of the brightness of a star, through the intervention of a comet, witnessed by Professor Reslhüber, of Kremsmünster, in the year 1846. The phenomenon is a very singular one, and not without a peculiar significance.

We must now particularize, in a very brief manner, certain remarkable appearances observed chiefly in great comets, some of which are inexplicable, without admitting the existence of a combination of forces of a totally different nature to any that we elsewhere meet with, and may not be without their bearing on the question at present under our consideration. In the first place may be mentioned, the occurrence of luminous jets or emanations of various, and frequently almost fantastic, forms issuing forth from the nucleus of the comet in different directions. In some cases, the jet sprouts out towards the sun, but after proceeding in that course a short distance, it is suddenly forced back again upon the nucleus, or curved round in the direction of the tail on either side of the head — a phenomenon irreconcilable with the principles of gravitation alone. Appearances of this kind were especially noticed in the comet of Halley when it was last visible (in 1835), and we are indebted to Mr. Grant, the author of the well-known

* In my descriptive treatise, entitled *The Comets.*

'*History of Physical Astronomy*,' for pointing out some very interesting observations of a similar character, which were made by Dr. Hooke, on the same comet at its visit in the summer of 1682, and also in that memorable body, to which we have so frequently had occasion to refer — the great comet of 1680-1. A few extracts from Hooke's observations will suffice for our present purpose: the reader who may desire to see a more detailed account of them, may consult the '*Posthumous Works*,' of this eminent philosopher (pp. 150-162, where he will also find Hooke's reasoning upon them.

On the 30th of December, 1680, Hooke has the following:—'I saw the same stream of light issue out of the nucleus as I had the night before, and this in the manner of a *sudden spouting of water out of an engine to quench fire*, which would presently again disappear, and be much like the rest of the blaze. These dartings I could perceive to rise to a considerable height into the blaze, or tail.'

The same appearance was remarked on the 7th of January, and again on the 9th, when we read:— 'This night again, as I had several nights before, I very often observed the sudden radiations or flashings from the nucleus, but especially in the middle of the pith or blaze. It was exceeding wonderful; and, all things considered, it seems very difficult to explain from what cause or by what means it was effected . . . Sometimes it would issue from one side and sometimes from another, and so shoot upwards into the pith of the blaze. Sometimes it would be dispersed, as it were, into a broad light and undefined,

whilst the other ascended straight and defined; and that also sometimes on one side and sometimes on the other, and seemed somewhat like the flaring of the flame of a candle or torch.'

On the 30th of January, 'the appearance was perfectly a resemblance of flame, but that exceeding thin and rarified, and of a faint light: it waved, flared or undulated to and fro; sometimes seemed to burn clearer and stronger, etc.' It was also remarked to be sometimes more on the side *near the sun,* and sometimes less. At one moment, for the twinkling of an eye, a very small bright point of light was visible in the centre of the head, which immediately vanished, and was 'covered with the white cloudy nucleus.'

In Halley's comet, the phenomenon was even more marked and unmistakeable. On the 26th of August, 1682, there were two luminous jets, one on the northern, and the other on the southern side of the nucleus. The most conspicuous of the two 'seemed like *a stream of flame blown out of a candle by a blow-pipe*, ascending or bending upwards just as such a blown flame of a candle will do, if it be made by a gentle blast.' The directions of the jets varied on the succeeding nights. On the 4th of September, Hooke observed 'the flaring or flashing of the light, and a kind of moving of the fusee on the north side.'

These 'tumultous changes,' as they are justly termed by Mr. Grant, were most unequivocally witnessed in the comet of Halley at its last appearance, as above stated. They were attentively

watched by Professor Bessel, the illustrious Astronomer of Königsberg, by Professor Struve, then director of the Observatory at Dorpat, and other eminent observers in Europe; and were likewise seen by Sir John Herschel, who was then at the Cape of Good Hope, engaged upon an examination of the nebulous contents of the southern heavens.

On the 2nd of October, Professor Bessel first remarked the existence of 'an effusion of luminous matter' from the nucleus, which he afterwards calls *the luminous sector*. On the 12th of the same month, the sky being very clear, he was enabled to continue his observations on the comet from sunset until three o'clock on the following morning, or over an interval of from eight to nine hours. In this lapse of time, it was found, by actual measurement, that the *direction* of the sector had changed in a remarkable degree: at six o'clock in the evening it formed, with the line joining the sun and comet, an angle of about 19°: at twenty minutes after two o'clock the next morning, the angle thus included was 55°, and the observations of preceding and subsequent nights exhibited similar alterations in the direction of this jet of luminous matter. The motion thus indicated, however, was clearly an oscillatory one, since, notwithstanding the constant existence of a considerable deviation of the axis of the luminous cone from the direction of the sun, it always returned to that line, to pass on the other side, i.e., the sector did not *revolve* about the comet's nucleus, but had a pendulum-like movement to and fro on the side facing the sun. On submitting his observations

to calculation, Professor Bessel found that the hypothesis of an oscillating motion in the place of the comet's orbit, the period of which, extended to 4 days 14 hours, would represent the whole without any very violent differences between computation and fact. Regarding this as a positive result of his observations, he then proceeds to show that the attraction of the sun, alone, could not account for it: any alterations thereby produced would necessarily be of long duration, whereas, it appeared, the oscillations of the bright jet had a very short period. Finally, he points out the necessity of admitting the existence of a polar force tending to direct one of the radii of the comet, towards the sun, and the opposite one in a contrary sense,—remarking that there is no reason, *à priori*, to reject the idea of such action. Terrestrial magnetism offers an example of a force closely analogous, though, adds Bessel, 'it is not yet proved that it refers to the sun.' (Since the illustrious astronomer wrote his memoir on Halley's comet, the connection between the sun's influence, or rather between the number of spots upon his disc and the magnetic declination has been *established* by the researches of General Sabine, and MM. Lamont, Schwabe and Wolf.) This force once admitted, the explanation of the movement of the cometary jet is attended with no difficulty, 'the duration of the oscillations will depend upon the magnitude of that force, and their amplitude, on a constant relative to the motion of the molecules.

The observations of Professor Struve, at Dorpat, in Russia, made with one of the most powerful

telescopes then in existence, are given at length in a special work upon the subject, entitled '*Beobachtungen der Halleyschen Cometen,*' and are illustrated with several drawings of the appearance of the bright jet and other phenomena. We have not space to describe these observations at length, and shall merely record their general confirmation, if that could be considered wanting, of those of Bessel. On one occasion, Struve compares the appearance of the sector to the flame issuing from the cannon's mouth.

The present Astronomer Royal, Mr. Airy, no doubt referred to the luminous jet of Bessel, etc., when, in observing the comet on the 18th of October, he stated his suspicion of a kind of *horn* projecting upwards from the nucleus.

Professor Bessel, in his paper upon the comet of Halley, draws attention to an observation, which he considered to bear upon the physical constitution of the nebulosity surrounding the nucleus. On the 29th of September, the comet passed very close to a star of the tenth magnitude; indeed, almost centrally over it: and the opportunity was taken of ascertaining whether any sensible *refraction* occurred, from the transmission of the light of the star through the atmosphere, or whatever term we may give it, of the comet. The result showed, that at a distance of only eight seconds of arc from the nucleus, which was the nearest approach, no refraction of the star's rays took place. There are other observations of a similar nature, including an important one on a star seen through Biela's comet at Dorpat: the inference

in every case has been identical with the above. To what does the fact point? Evidently, as Professor Bessel remarked, it demonstrates that the nebulosity of a comet is not a *gas*,—at least, there is no gas yet known, which would be without an effect on the transmission of light. We may here observe, that the term *gaseous*, often applied to these bodies, should not be understood in an absolute, but rather in a comparative sense.

Other curious phenomena, at variance with our ordinary notions of the gravitation of matter, were remarked by Sir John Herschel, and will be found described in his '*Results of Astronomical Observations at the Cape of Good Hope*.' Speaking of the tails of comets, Sir John observes, 'If they be material in that ordinary received sense which assigns to them only inertia and attractive gravitation, where, I would ask, is the force which can carry them round in the perihelion passage of the nucleus, in a direction continually pointing from the Sun — in the manner of a rigid rod swept round by some strong directive power, and in contravention of all the laws of planetary motion, which would require a slower angular movement of the more remote particles, such as no attraction to the nucleus could give them, supposing it ever so intense?' In Halley's comet, 'the matter of the tail seemed to be emitted in violent jets and streams, as if from orifices or fissures in the anterior part of the nucleus.' The same eminent physicist expresses the opinion that, 'a high degree of electrical excitement in the matter of the tail (of the same character with that of a permanent electrical

charge supposed to be resident in the Sun) superadded to the ordinary conception of a gravitating nucleus, would satisfy most of the essential conditions of the problem;' and adds—'I see no part of the phenomena of a comet which appears to stand out as irreconcilable with this view of the subject.'

When Biela's comet was visible in 1846, a circumstance of a most unexpected and astounding nature took place under our immediate observation. At the end of December, or early in January, the comet separated into two distinct portions, each of which had the appearance of a separate comet, with something approaching a nucleus and a short tail.

While they continued within reach of the telescope, their distance from each other was about two-thirds of the distance of the Moon from the Earth; but on the re-appearance of the comet in the autumn of 1852, when both heads were again recognised and their places determined, it was found that their mutual separation had greatly increased,* —to such an extent, indeed, that henceforward we shall probably have to treat them as two distinct bodies. There was reason to suppose the *mass* of each excessively small, since no appreciable perturbations were produced by either upon the motion of the other. To what agency are we to attribute this disruption of a comet, which, since the year 1772, when it was first known, had never presented itself,

* Professor d'Arrest computes their distance, in 1852, at from six to seven times the radius of the Moon's orbit, or about 1,500,000 miles.

except under the ordinary aspect of the great majority of such bodies — as a faint or only moderately bright nebulous object, with a condensation of light near the centre? No plausible explanation of the phenomenon has yet been offered, so far as we are aware. It points, however, to the existence of some unknown force in the comet itself, which, in this instance, was sufficiently powerful to overcome the attraction that might be supposed to belong to the nucleus as it previously existed.

Enough has probably been said to satisfy the reader, that comets — to use Sir John Herschel's words — 'belong to a different class of existences' — from any other that we meet with in the solar system — that while the masses of the vast majority of these bodies are infinitesimally small, they cannot be regarded in every case, as mere collections of excessively attenuated vapour, — but that they exhibit indisputable symptoms of the action of a force which assimilates more nearly to that of electricity in its most imposing forms, than with any other with which we are acquainted.

With all these facts before us, let us now return to the consideration of the question last proposed — *Is danger to be apprehended from the near approach of a comet to the Earth or from its collision with our globe?*

As regards the chance of *mechanical danger,* so to speak, consequent on the actual *shock,* if such it can be termed, of a comet, even though it were moving in an opposite direction to that of the Earth in her orbit (or with a possible velocity of some 40 miles per

second), we may rest assured there are few, if any of these bodies, constituted of materials of sufficient density or solidity to produce very unpleasant effects in the event of a collision. Popular apprehension, when comet-panics have arisen, has been almost exclusively confined to this view of the kind of danger involved in an encounter with a comet — the blow of a large mass capable of producing by the mere force of concussion the most disastrous consequences to mankind. Such an occurrence, however, is by no means consistent with our present knowledge of the nature of comets. At the worst, a direct collision would perhaps be comparable only as regards the mechanical effect upon the earth to a meeting with a huge cushion.

Neither is there any reason for apprehension of the effect of a comet's *attraction* upon the waters of our globe, occasionally hinted at in astronomical works, chiefly in those of the last century. It may be mathematically demonstrated, that, even allowing a comet to be of nearly equal mass with the Earth, it could not remain long enough in a position to operate upon the Ocean in such a manner as to overwhelm the continents, and thus lead to calamitous consequences. Those who may be curious on this subject, will find ample information in a work published many years since by Du Séjour, a well-known French Geometer, entitled *Essai sur les Comètes.*

Dismissing, then, the idea of any mechanical danger from actual collision, we have to notice the possible effects of a *sudden commingling of the nebulosity of a comet with the earth's atmosphere,* an occurrence involving

considerations of quite a different nature from the preceding. With our actual knowledge (imperfect though it may be) of the existence and probable origin of those tremendous forces so conspicuously visible in their effects in the comets of 1680, 1835, etc., and which, as we have seen, there is every reason to suppose analogous to electricity and magnetism in their most powerful states of development, it is hardly too much to say, that our immersion in the head of such a comet, *might* be attended with serious consequences. Whether we should escape with the temporary derangement of our compasses, the disorganisation of our telegraphs, with electrical storms of unprecedented extent and violence, and startling exhibitions of auroræ, etc., or whether the electrical equilibrium of the atmosphere would be so completely overthrown, as to occasion events of a disastrous character, and more easily imagined than described, must necessarily be open to speculation. This, however, we are inclined to think is the *kind of danger*, if any there be, involved in a collision with a comet. Sir John Herschel, alluding to the possibility of the earth's having passed through the comet of Biela in 1832, had it arrived a month later in perihelion, terms the meeting of the two bodies 'a singular rencontre, perhaps not unattended with danger.' But, since Biela's comet is one of the most filmy and pellucid of these objects, that distinguished philosopher can hardly have contemplated injury such as must follow the shock of a solid mass, and possibly may have had in view a similar catastrophe to that at which we have ventured to hint.

Yet, however dismal a view may be taken of the probable results of a collision of the earth with a comet, there is a bright side to the picture. Hitherto we have carefully distinguished the danger to be apprehended from contact with a comet from the probability of the event itself. Let us now proceed to inquire—

VIII.

Is the collision of a Comet with the Earth an event of any probability?

TO this question it may be replied that the *chances* against such an occurrence are overpowering: it is possible, but in the highest degree improbable.

As regards the comet of Charles V., which is now looked for, so long as it retains the form of orbit, which it possessed when last visible to us, it can never approach near enough to the earth to justify the least alarm. To bring this body upon the path of our globe (i. e. to render a collision possible), we should require to make alterations in the position of its orbit, as determined from the observations of 1556, which those observations by no means warrant or will admit of, and it is very unlikely that such alterations will be made by the attractions of the planets. To increase the chances against a near approach or collision, it is only necessary to reflect that even if the comet, at either of its passages through the plane of the earth's path happened to be precisely at the same distance from the

sun as the earth, in that part of her orbit, there is only one day in the year upon which the nearest proximity to the sun could fall, which would bring the two bodies into contact. If the comet passed this point on any other day in the three hundred and sixty-five we should be safe.*

Nor is this comet likely to vouchsafe us a lash with its tail. It is true that if it arrived at the lower end of its ellipse (in astronomical language—*passed its perihelion*) about midnight on the twenty-first of August, the earth would be enveloped in the tail on the twenty-second of September, provided its length exceeded thirteen millions of miles in the line joining the sun and comet. Here again, however, we encounter the vast array of chances against the occurrence of the exact combination of circumstances required to produce the result.

The probability of a collision is equally remote, even if we extend the risk to comets generally. The chances are still as hundreds of millions to one that no such event takes place. M. Arago has remarked, that if we knew no more of a comet, than that, at its minimum distance from the sun, it stood within

* The comet of Biela crossed the earth's orbit in 1832, at so small a distance therefrom, that, had we happened to have been situate in that neighbourhood at the time, we might have come in contact with it. However, we were far removed from this part of our annual track, and so escaped. So long as the comet retains its present path in the system, we shall pass very near it on the thirtieth of November, when it arrives at its least distance from the sun on the twenty-eighth of the following month.

the orbit of the earth, and had a diameter of one-quarter of that of our globe, the mathematical theory of probabilities shows, that the odds would be 280,000,000 to 1 against its coming into contact with us.

Hence we derive our assurance of safety from any injury owing to the near appulse or shock of a comet. We repeat, the event is one that *can* happen; but there is an overwhelming number of chances adverse to its taking place. History will no doubt furnish other instances of 'comet-panics' in addition to those already on record, yet we may safely predict they will always prove equally void of foundation.

IX.

On the Distance of the Comet of 1556 *from the Earth: its Duration of Visibility and Degree of Brightness.*

THE *nearest approach of the Comet to the earth* at any of its appearances, is dependent wholly on the time of year at which its perihelion passage falls. The closest proximity of the two orbits occurs near the points where their planes intersect each other, since the distance of the earth and comet from the sun are there nearly equal. These points of intersection now correspond almost precisely with the commencement of the signs Aries and Libra, wherefore it is easy to see, that the *least distances* between comet and earth can only take place about the equi-

noxes, or more exactly, on March 17th and Sept. 18th; because upon those dates only can the earth pass near the positions where the comet crosses our path at the same time as that body. On or about March 17th, we might be within 6½ millions of miles from the comet, or, in round numbers, we may take six millions as the *least possible* distance at which we can pass, so long as the orbit of 1556 remains unchanged. At the autumnal equinox we could not be even so close as this. If the perihelion passage were to occur about the first of January, our distance from the comet would always exceed 135 millions of miles, or about half as far again as the earth is from the sun.

The *duration of visibility* must chiefly depend upon the time of year when the comet reaches its perihelion, though partly upon the intrinsic brightness of the nucleus. In 1264, it was remarked from the middle of July until the beginning of October: in 1556, from the last days of February to the middle of May; but, if the comet should again arrive at the lower end of its ellipse about July 15th, as in 1264, we might expect to be able to follow it on its journey with the aid of telescopes, several months longer than it was traced in that year.

The *degree of brilliancy* of the comet involves the same conditions. The orbit is so situated, that the path in the heavens cannot be favourable for observation in any part of the earth, unless the time of perihelion falls between March and October. This admits of easy explanation. When the comet is nearest the sun, its longitude, as observed from that

luminary, is in the 8th degree of Capricornus, which is the sun's place a few days after Christmas. Consequently, as viewed from the earth, both sun and comet are in the same part of the heavens in midwinter, and the latter, near perihelion, is overpowered by daylight, besides being at a great distance from us. So far from its proving a conspicuous object in the sky, if the arrival at closest proximity to the sun happens in the winter months, it is very probable that no small difficulty might be experienced in observing the comet at all; hence the necessity for a very careful and well-arranged search at this season of the year. On the contrary, if the perihelion passage occurs in the summer half of the year, we may calculate upon the presence of a conspicuous, if not a grand object, in the heavens—supposing the comet has not degenerated since its visit in 1264, which, from the observations of 1556, we see no reason to suspect.

An eminent Italian Astronomer, Professor Carlini, of Milan, formerly one of the most active labourers in the field of cometary science, would appear to entertain a different opinion: he argues,—that even in the event of the comet's re-appearance, we must not look for a brilliant object, or, at least, an object comparable in grandeur to that of 1264. To this we reply—the comet was observed under widely different circumstances in 1556, to those attending its previous visit. In 1264, it was most favourably placed for observation immediately *after* its closest approach to the sun,—in 1556, though much nearer to the earth, it was observed only *before* the perihelion.

Now this fact, we incline to think, would quite account for the less brilliant aspect of the comet in the latter year. As a general rule (exceptions do occur), these bodies assume the most imposing appearance, and exhibit the longest tails when they are favourably situated with respect to the earth *after* their nearest approximation to the sun, when his influence, which is undoubtedly mixed up in some way with the formation of the tail, has arrived at a maximum. Thus we might cite in support of our view, the comets of 1618, 1668, 1680, 1689, 1811, and 1843. The comet of 1769 stands out an almost solitary instance in modern times, where at a considerable distance from perihelion, and *before* reaching that point, the tail stretched over an arc of the heavens of 80° or 90°. What the appearance of that comet would have been, if it had been well placed for observation after its nearest approach to the sun, it would be impossible to say.

In 1264 the comet exhibited a tail which, by the concurrent testimony of European and Chinese historians, was upwards of 90° long: it was remarked several hours before the nucleus ascended above the horizon, and, as one of the old chronicles tells us, 'spread out far and wide.' In 1556, there was no such imposing train, but the brightness of the head was greater, we think, than several late writers have supposed. The comet was seen in China 'during four moons,' though the distance from the earth towards the end of the interval must have been considerable. Claude Comiers, alluding to the theory of Aristotle, which ascribed the presence of comets

to the ignition of exhalations from the earth, remarks, that it was impossible terrestrial exhalations could be furnished to 'that prodigious comet (1556) which with such wonderful brightness ran from the equator to the Great Bear, since all the wood in the world would not make so great a fire, during so long a time.' Joachim Heller first saw this comet on the 27th of February, eight weeks before the perihelion passage, and while it was situate less than 10° from the moon, then only sixty hours past the full. Even under these unfavourable conditions, he describes it as a 'very great, fiery, extraordinary star'; and we might infer it was as bright as the more conspicuous planets, since Heller distinctly alludes to Jupiter and the others being below the horizon or elsewhere placed at the time, as a reason for supposing he had discovered something new. It will be understood, that we attribute the absence of the huge tail of 1264 to the fact of the comet's being most advantageously situated for observation in 1556 *before* the perihelion passage, but that at the same time there is sufficient evidence to prove, that the nucleus must have been very brilliant.

X.

Remarks on various points connected with Cometary Astronomy.

IT is frequently asked of those who are supposed to be conversant with astronomical details — *What is the real velocity of such and such a comet?* Though it is scarcely probable that any one would be prepared to give an immediate answer to a question of this kind, the required information is very readily obtained when certain data are given. Indeed, the momentum of a comet at any point in the orbit which it describes about the sun, depends upon its distance from that luminary; it is greatest when this distance is least, and *vice versâ.*

The great comet of March, 1843, attained an almost incredible velocity about the 27th of February, when it passed nearest to the sun, and so close as to have narrowly escaped contact with him. In this part of its track, it travelled at the rate of 360 miles in a second, 21,750 miles in a minute, or upwards of 1,300,000 miles in an hour. Startling as such numbers appear, we know they must nevertheless be true, being founded on deductions from the universal laws of gravitation expounded by Sir Isaac Newton. The celebrated comet of 1680 moved with a velocity scarcely inferior to that of the comet of 1843.

In strange contrast with this lightning speed, are the velocities of some comets when furthest removed

from us. That of 1843, according to the most probable assumption we are able to make as to the distance to which it recedes, will then travel only at a rate frequently attained on our broad-gauge lines of railway; while the comet of 1680 will move no quicker than a horse can trot!

It is evident, therefore, that a comet's momentum is a very variable affair, and must be determined specially for that point in its orbit at which it is situate at the time we are desirous of knowing its rate of motion.

The expected comet of 1556 travels with velocities varying according to its distance from the sun, between 429,000 miles and 755 miles per hour.

The finest comets which have been observed during the present century are those of 1811 and 1843. The former one was more remarkable for its brilliancy and the length of time it continued visible, than for the apparent extent of the tail; indeed, we have frequently met with eye-witnesses of that comet who have no recollection of any vestige of a tail. As seen from the earth when the head was most conspicuous, the train was a good deal foreshortened, and the longest distance to which it could at any time be traced, appears to have been about 25° in the middle of October. Sir W. Herschel's estimate of 23½° on the 15th of that month, corresponds to a real length of 108,000,000 miles, if the tail was exactly in the line joining the sun and comet; but, on this point, there may be much uncertainty. The drawings, which were made at the time generally exhibit the comet with a broad, curved tail, of only

moderate length, and sometimes divided by a dark line near the middle. But if this comet fell short of the other *great* ones, as regards the *apparent* extent of the train, there can be little doubt that it was yet one of the largest bodies of the kind that has been hitherto observed. The diameter of the nebulosity surrounding the nucleus was considerably more than 1,000,000 miles, or about five times the radius of the moon's orbit. Though chiefly conspicuous to the naked eye in the autumn of 1811, when its presence was thought to have had a beneficial effect upon the vintage of Southern France,* it was seen with the telescope nearly sixteen months, or from the 25th of March, 1811, to the 17th of August, 1812. It is well known to have been regarded by many superstitious minds as the baleful star of Napoleon, and the precursor of the disastrous expedition to Russia, which was on foot before the comet had travelled far beyond unassisted vision. There is a tolerable certainty, that the period of revolution, while observations were possible, was somewhere about 3,000 years: it is likely, however, that the next return of the comet to these parts of the system will be greatly accelerated by the perturbations of the planets, and before the good year A.D. 4,000 the annals of astronomy may have again recorded its visibility from the earth.

The other comet to which we have alluded, that of March, 1843, was very disadvantageously placed for observation in these latitudes: the nucleus was

* Who has not heard of the 'Comet-wine' of 1811?

scarcely seen in England,* though found at many of the observatories of Southern Europe without difficulty. The tail covered an arc of the heavens of more than 40°, even in the hazy atmosphere which commonly prevails in the early evening hours in London, but was not brilliant: it rose above the vapours of the horizon in the west, and stretched out in a southerly direction to the stars in Lepus and Canis Major, below the belt of Orion. On the 17th of March, when it appears to have been suddenly visible, not only in England, but in other countries, the tail had sufficient light to attract very general attention as an unusual phenomenon; and there are few readers of these pages who will not remember the excitement it produced, more especially as its true character appeared for a time doubtful. The aspect of this comet in the southern parts of the world has been described in glowing terms, and we should imagine it is the only one that has appeared since the year 1769, which will bear comparison with the enormous comets of the seventeenth century. It was found in broad daylight, and even *close to the sun*, on the 27th of February, at Concepcion, in South America; and on the following day was again perceived only 3° or 4° distant from the sun's centre in various parts of the earth: it was as well defined as the moon on a clear day, and in Italy was seen directly the sun was kept out of view by allowing a wall to intervene. In America,

* Sir John Herschel was probably the only observer in this country.

a great number of persons saw it on this date; and it was also remarked on board ship off the Cape of Good Hope. Its real distance from the sun was subsequently found to be even less than that of the comet of 1680 in its perihelion, indeed, little more than 90,000 miles. It moved away from us so nearly in a straight line, that great doubt necessarily exists on the nature of its true orbit in the system, though, with some appearance of probability, the period of revolution is thought to be less than 200 years: direct calculation, however, assigns, we believe, nearly four centuries. In some of the West India Islands, and in different parts of South America, the comet occasioned much consternation. In Europe, as we have stated, it was never particularly bright, and always unfavourably placed for a view of its whole extent, so that it excited nothing beyond a very natural curiosity.

What would now be the effect in some quarters — even in the boasted centres of civilisation — were a grand comet like the memorable one of 1680 to suddenly visit us, and exhibit in our northern heavens its flashing nucleus and coruscating tail of 70°, 80°, or 90°— covering half the expanse of the sky — may be a subject for speculation; though who would venture to affirm, after recent experience, that a repetition of some of the scenes which are related to have followed the appearance of the comet of 1680 might not be witnessed, or that announcements calculated to allay the fears of the timid and uneducated would not be as much called for at the present day, as they were when Dr. Wetenhall, the Bishop

of Cork, wrote his pamphlet * to calm the apprehensions of 'diverse persons who were so strangely struck that their faces were grown almost like the comet, only of a blacker pale'?

There can be no doubt that comets of a faint description frequently pass by us unobserved; and it is equally certain that others of a brighter character occasionally escape without our procuring a sufficient number of positions to enable us to institute any calculations respecting their orbits. In the southern hemisphere, the few astronomical observa-

* Dr. Wetenhall soundly rates the Astrologers for their share in the promulgation of the most absurd notions relative to the effects of comets on terrestrial affairs. He writes: 'They affirm those comets in the figure of a spit (sharp, slender and of indifferent length) to be most mischievous in their effects. Of this sort have many appeared, and the artists tell us, saith my author, their events are slow but sad. I'll omit that of 1558, and look back to 1391, as more remarkable in its operations. For about a year after Bajazet sat down before Constantinople (lesser accidents we'll take no notice of), and after seven years the siege was raised, and he being taken by Tamerlain was put into an iron cage, and carried so in triumph through Asia. Had he been trussed and roasted, the prediction had had some shadow of analogy. We ought to understand common people are not fit to foreknow, and 'tis below these gentlemen to foretel (that is, to particularise) any event till it is come to pass. For if people seeing a spit, were at the same time told they were to understand a cage, they are so dull, it would not be beaten into their heads. * * * Can any man alive say that in eight or nine years (the time demanded *ex post facto* to intervene between the comet and Bajazet's fall) a spit might not be forged into grates? Well, then, the fiery spit did signifie Bajazet's cold iron house, and they are ignorant fools that deny it.'—*A Judgement of the Comet* (1680) p. 13.

tories at present in existence are too much engaged upon what may be termed standard astronomy, to afford time for a systematic search after comets, without which it is more than probable that many are likely to elude observation — more especially if they only traverse those constellations which are invisible in Europe. Bright comets have sometimes passed with the bare record of their presence, owing either to their position in strong twilight, to atmospheric circumstances, or to their paths being unfavourable for observation in those parts of the world which are best provided with the proper instruments. A case of this kind occurred in November, 1849, when a comet with a very distinct nucleus, about as large in appearance as the planet Mars, and with a tail several degrees long, and of a curved figure, was remarked for about twenty minutes on board ship off the north-east coast of South America. It was near the horizon, and soon obscured by clouds; nor was it found on subsequent evenings. Again, so recently as August, 1856, the newspapers announced the presence of a bright comet which had been some time visible for about two hours every evening, at Acapulco and other places on the Peruvian coast, but as yet we have no further knowledge of its position in the heavens.

We may hope that the establishment of a well-equipped observatory at Santiago de Chile — now in active operation — may render such cases of less frequent occurrence, yet we will venture to suggest to our readers, that if any of them should happen to be situated in parts remote from astronomical sta-

tions when a comet is seen, they may very possibly do good service by estimating its position in the heavens with reference to neighbouring stars, as best they can, no matter in how rough a manner, but of course the more carefully the better.

If instruments are wanting, the comet's place may be indicated by alignments with stars in its vicinity, or it may be marked down on a celestial chart or globe: in any case the *time* must be noted, and it is necessary to bear in mind, that *three* complete positions at the least are required to determine the orbit. Such data would obviously lose much of their value if the comet should happen to be observed with precision elsewhere, but in cases similar to those we have just mentioned, they would possess a high degree of interest and importance.

Comet-hunting is very well adapted to the means of those numerous amateurs of astronomy, who may find the powerful telescopes required in some other branches of the science beyond their attainment. The only instrument that is essential for the prosecution of an active search is a 'comet-seeker'— a telescope of large aperture which allows of a thorough examination of the heavens in a much shorter time than it could be accomplished with one possessing a smaller field of view. Such instruments are well known on the Continent, but not so much as they deserve to be in this country: indeed, without intending the least disparagement to the resources and energies of English opticians, we may safely state, that a *comet-seeker*, comparable with those supplied by the famed workshops of Berlin or Vienna, has not

yet been turned out of an English manufactory. The want of indigenous instruments, if we may use the term, has arisen no doubt from the absence of a demand for them — not from any difficulty, as matters now stand, in their supply.

'Comet-seekers' of the better kind are very well adapted for other work than that for which they were specially devised. They will show stars of the eleventh magnitude, and consequently are capable of following many of the small planets in their courses amongst the fixed stars. They will bring out some of the most interesting features of the planets Jupiter and Saturn; and in these days, when the uranography, or mapping down the contents of the heavens is attracting marked attention, though not beyond the great importance of the subject, as regards the present and the future, we doubt if a more convenient and suitable instrument is available.

A *comet-medal* was instituted many years since by the late King of Denmark, but has been discontinued by his present majesty. It was awarded to the first discoverer of a telescopic comet; and, without doubt, occasioned a very active competition amongst those observers who devoted their time and attention to the observation of these bodies. The judges were the late Professor Schumacher, of Altona, the distinguished editor of the *Astronomische Nachrichten,* which still retains its reputation as *the* astronomical periodical of the day; Professor Gauss, the late director of the Observatory at Göttingen; and our Astronomer Royal, Mr. Airy. The Denmark medal was of gold, and its value, twenty Dutch

ducats, with the inscription—'*Non frustra signorum obitus speculamur et ortus.*' The foundation of a similar medal by one of the learned societies of Europe, would be very likely to give an additional impulse to the search for comets: nevertheless, it would be unjust to imply that any want of zeal has characterised the operations of practical astronomers as respects cometary discoveries since the discontinuance of the Denmark medal. On the contrary, it not unfrequently occurs, that the same comet is found independently by several observers; and in this honorable rivalry the new world has claimed an active share, through the exertions of Mr. G. P. Bond, Mr. Van Arsdale, and others. The last comet announced was separately found at Göttingen, Paris, and Gotha.

Everyone who has the least acquaintance with astronomy, will be aware that there are in the heavens a vast number of objects of a nebulous, cloudy appearance in the ordinary telescopes, which have frequently been mistaken for comets. These objects, to which the general term *nebulæ* is applied, are, however, catalogued extensively, chiefly by the labours of the two Herschels; though Messier, a French astronomer, and a well-known hunter after comets,* who must have experienced the want of such a list of nebulæ, published, about three-quarters of a century ago, the positions of the brighter objects of this class. The great nebula in the girdle of

* In consequence of his numerous discoveries he was called '*the comet-ferret.*

Andromeda, aptly compared to 'a candle shining through horn,' has been repeatedly mistaken for a comet by the uninitiated or inexperienced; and the same may be stated of other cometary-looking objects of the like nature. They are, of course, eventually distinguished from comets by their *fixity* in the sky; nevertheless, it will be found desirable to possess a tolerably complete list of nebulæ, especially of the brighter classes, in order to save both time and trouble. For this purpose, the great catalogue of Sir John Herschel, published in the *Philosophical Transactions* for 1833, will be the best help, particularly if used in conjunction with the list contained in Admiral Smyth's *Cycle of Celestial Objects*, which, we believe, enumerates such of the more conspicuous nebulæ as did not occur in the "sweeps" of Sir John Herschel. Professor d'Arrest, of Leipsic, is now occupied with the preparation of a catalogue of nebulæ, which will eventually prove very useful to the comet seeker.

Allusion has been already made to one method of determining the period of revolution of a comet, which was applied, though under unfavourable conditions, to that of 1556, and more satisfactorily in the case of the comet of Halley: if the orbits of comets appearing in different years are very similar, there is a strong presumption in favour of their identity. There are cases, however, where the time of revolution may be ascertained with a greater or less degree of accuracy, from the observations of a single appearance. If a comet's period is short—say less than ten years (there are many such)—and

it has been well observed for a considerable length of time, six or eight weeks for instance, the epoch of the ensuing return may be foretold with no greater error than a few days. The longer the period, or in other words, the more eccentrical, or elongated, the orbit, the greater is the difficulty and uncertainty attending the calculation, so that, as we approach periods of excessive length— of many hundreds or thousands of years, it is scarcely possible (except in a few very rare cases), to assign the times of revolution with any degree of confidence, because small changes in the positions of the comet, as viewed from the earth, may correspond to greatly magnified alterations in the periodic time. It will happen occasionally, even if the revolution be short, and the comet is very carefully observed, that from other causes a great deal of uncertainty may attach to the date of its next arrival at perihelion. As an instance—Professor d'Arrest's comet, of 1851, was assiduously watched for upwards of three months, and its period appeared to be no longer than about seven years, yet there is a doubt amounting to eighty days in the time of its ensuing return; and again—the comet detected by Mr. Brorsen, in February, 1846, which also visited these parts of the system in 1851, but could not be observed, from its unfavourable position, was calculated to arrive at its least distance from the sun towards the end of June, 1857: it actually reached that point in the month of March preceding; thus exhibiting an error of prediction of about three months, which was unavoidable, regard being had to the circumstances attending its visit in 1846. The reader

will understand that, although, in some cases, it is possible to determine a comet's period from the observations of one appearance only, this by no means occurs frequently; and the problem is open to various degrees of success in its solution. We repeat, that when the time occupied in a journey round the sun is found to be very long,—any result must be open to doubts, unless the conditions are unusually favourable for the calculation.

Now, including all the comets, the periods of which may be considered as ascertained with varying degrees of probability on either of the methods we have described, there are very few with revolutions exceeding in duration that of Halley's comet (three quarters of a century), but less than five hundred years. Perhaps the most satisfactory-looking agreement of elements in different years, occurs with the comets of 1596 and June, 1845, whereby a period of 249 years is surmised: but it unfortunately happened, that the comet of 1845 was not observed long enough to allow of a direct calculation from the positions of that year, which, if found to indicate a period approaching the above, would have definitively settled the question: all we can say respecting it is, that the few observations taken in 1845 may be represented by a revolution of two and a half centuries, which accords with the supposition of an appearance in 1596, yet, so far as those observations are concerned, a very much longer period is possible. The calculations of Mr. Götze assign a revolution of about 350 years to the telescopic comet discovered by Dr. Bremicker at Berlin, in the

autumn of 1840, and afford perhaps the best determination of a period within the above limits that we possess; indeed, we believe it may be said to be the only one upon which reliance can be placed.

It will not be a matter of surprise, therefore, that the anticipated return of the comet of 1556, after a journey of three centuries' duration, is invested with a peculiar interest to the astronomer, and one quite independent of the appearance presented by it when within our range of vision. Whether it exhibits the grand spectacle of 1264, or the faint, vapoury aspect of most of the comets that are observed, its return would still be equally welcome to him, as forming an epoch of some importance in the history of cometary science.

Three centuries may appear a very long interval of time to be occupied by a single revolution of a comet, yet the furthest distance to which such an one would recede from the sun is quite insignificant when compared with the enormous space that separates the central body of our system from the nearest of the fixed stars.* In July, 1844, the late M. Mauvais of Paris discovered a comet, which was observed, with slight intermission, until March following. Upwards of five hundred positions were accurately registered in the eight months of the comet's visibility; for when it descended below the horizon to European observatories, it was assiduously watched

* The *aphelion* distance of the comet of 1556, if identical with that of 1264, will be about 90 times the earth's distance from the sun.

at the Royal Observatory of the Cape of Good Hope by the present able director, Mr. Maclear. So favourable an opportunity of determining the orbit of a comet has seldom been afforded; and an elaborate investigation was entered upon, as might have been expected. Professor Plantamour, of Geneva, in a *Mémoire sur le Comète Mauvais de l'Année*, 1844, deduces the period of revolution corresponding to the *ensemble* of observations, and it is no less than 102,000 years! With such a period, the comet would recede from the sun to more than 4,350 times our distance from him; but even this enormous separation is a mere fraction of the distance of the nearest stars. In the southern constellation, Centaurus, is a bright star, which does not rise in these latitudes. From some peculiarities which we need not detail here, this star has been an object of very careful observation at the Cape of Good Hope; and it has been found to exhibit a greater *parallax* than any other hitherto examined, i.e. as viewed from opposite sides of the earth's annual orbit, its position has changed to a greater extent than in any other instance. This alteration of place corresponds, however, to the almost inconceivable distance of 200,000 times the earth's distance from the sun: nevertheless, the bright star in Centaurus is, so far as we know at present, the nearest of the fixed stars.

Mauvais' Comet, with its revolution of 102,000 years, can attain little beyond one-fiftieth part of the distance which separates us from the sidereal heavens. As a matter of curiosity, let us see how long a comet would be in reaching the bright star in

Centaurus, or what period it must have for the furthest point of its orbit to be situate at the distance of that star. This is a very easy matter: taking the greater semi-diameter of its ellipse at 100,000 times the radius of the earth's orbit, cubing this number and extracting the square root (which by the known laws of elliptic motion is the rule for finding the time of revolution in years from the greater semi-diameter of the orbit), we find that no less than 30,000,000 years* would be required for a single journey; or the comet would not reach the star until after a lapse of 15,000,000 years from its visibility to the earth. We doubt if it is possible to offer a more striking illustration of the prodigious distances of the fixed stars, or of the awful extent of space beyond the known limits of the planetary system, in which comets may pursue their dreary paths — possibly the sole denizens of that tremendous abyss.

This and like considerations may well excite our amazement, and raise in us the desire to learn something respecting the purpose which these extraordinary bodies are destined to fulfil in the economy of the universe. That some great secret of nature is involved in the cometary creation, we cannot venture to doubt; and the time may not be very distant when the progress of science, rapid as it now is, may afford some clue to its solution.

* In round numbers; the actual amount is greater.

THE END.

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